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# Environmental Effects of Dredging Technical Notes



## SYNTHESIS OF LEACHING RESEARCH AND WORKSHOP RESULTS

PURPOSE: This technical note briefly describes the results of recent studies conducted to evaluate leachate quality for dredged material in confined disposal facilities (CDFs). Directions for future research from a workshop on development of leach tests for contaminated dredged material conducted in Baton Rouge, LA, on June 23-24, 1988 are also provided.

BACKGROUND: Contaminated dredged material is sometimes placed in confined disposal facilities where potential for the movement of contaminants by leachate into groundwater and surrounding surface water is an important environmental concern. There is presently no routinely applied laboratory testing protocol to predict leachate quality and quantity from confined dredged material disposal facilities. In 1984, the Corps of Engineers initiated confined disposal facility leachate investigations by developing a theoretical framework for prediction of leachate quality based on mass transport theory. A preliminary laboratory program including batch and column leach tests was designed on the basis of the theoretical analysis and a literature review. Batch tests provide a quick, relatively easy method for determining the distribution of contaminants between dredged material and leachate. Column tests more closely approximate field conditions in a confined disposal facility, but require more time and equipment than batch tests. The approach recommended for application to dredged material used an operationally defined equilibrium distribution (partitioning) coefficient to relate aqueous phase concentration to solid phase concentration. Reviews and comments on the proposed approach were received from a technical working group assembled at the US Army Engineer Waterways Experiment Station (WES) in 1984.

The approach recommended for application to dredged material was used in studies at Indiana Harbor, IN; Everett Harbor, WA; and New Bedford Harbor, MA. Results of these studies provided site-specific information for use in management-level site selection treatment and control technology assessment for dredged material. Results of these studies were also evaluated in 1988 at a workshop in Baton Rouge, LA, hosted by Louisiana State University. The workshop provided outside critical review of past studies and direction for future research in this area.

ADDITIONAL INFORMATION OR QUESTIONS: Contact one of the authors, Mr. Tommy E. Myers, (601) 634-3939, or Dr. James M. Brannon, (601) 634-3725, or the manager of the Environmental Effects of Dredging Programs, Dr. Robert M. Engler, (601) 634-3624.

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## Introduction

At present, there is no routinely applied laboratory testing protocol capable of predicting leachate quality from confined dredged material disposal sites. Testing procedures to predict leachate quality are, therefore, needed in order to fully evaluate the confined disposal alternative for dredged material. If leachate quality and quantity can be predicted, the potential impacts of contaminated dredged material disposal in a confined disposal facility (CDF) can be determined, thus allowing the most cost-effective site design to be used.

Experimental procedures for predicting leachate quality have been used to evaluate the potential impacts of confined disposal of dredged material from Indiana Harbor, IN; Everett Harbor, WA; and New Bedford Harbor, MA (Environmental Laboratory 1987, Palermo et al. in publication, Myers and Brannon in publication). These procedures were based on theoretical analysis and a literature review as well as reviews and comments by a working group of experts held at the US Army Engineer Waterways Experiment Station (WES) in 1984 (Hill, Myers, and Brannon 1988). Results of laboratory studies conducted to date are briefly summarized in this technical note. Also included are directions for future research, which were developed at a workshop held at Louisiana State University in 1988; the proceedings of the workshop are available from WES upon request.

## Methods

Batch tests (shake tests) were conducted to investigate contaminant release properties of sediment under anaerobic (oxygen free) and aerobic conditions. Batch testing procedures applied to dredged material included kinetic tests, liquid-solid ratio testing, and sequential batch testing. Kinetic batch tests determine the shaking time necessary to achieve steady state (i.e., no detectable change in leachate concentrations). Liquid-solid ratio batch testing is conducted to find the optimum sediment-water ratio for

use in batch testing. Sequential batch testing is used to determine the distribution of contaminants between sediment and leachate. Such testing is conducted by shaking sediment and water until steady-state leachate concentrations are reached, separating the sediment and water, adding fresh water to the solids, and continuing the shake tests. The leachate removed at each step of the procedure is chemically analyzed.

Continuous flow column leaching tests were conducted in divided-flow stainless steel permeameters designed to minimize wall effects and provide for pressurized operation (Figure 1). The applied pressure (maximum of 25 psi) forced water through the sediment at rates sufficient to allow sample collection in a reasonable period of time.

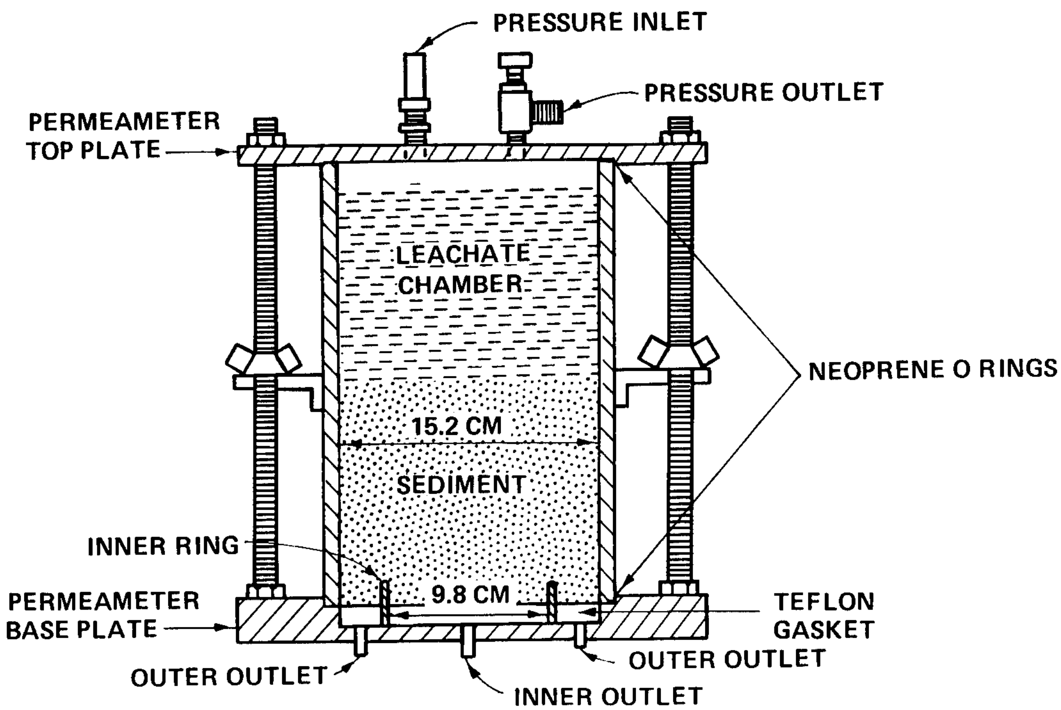


Figure 1. Divided-flow permeameter

Results of column and batch leaching tests were compared by integrating batch leach tests and column leach tests with a mass transport equation to predict permeameter leachate quality as a function of volume throughout (time). The approach used is outlined in Figure 2.

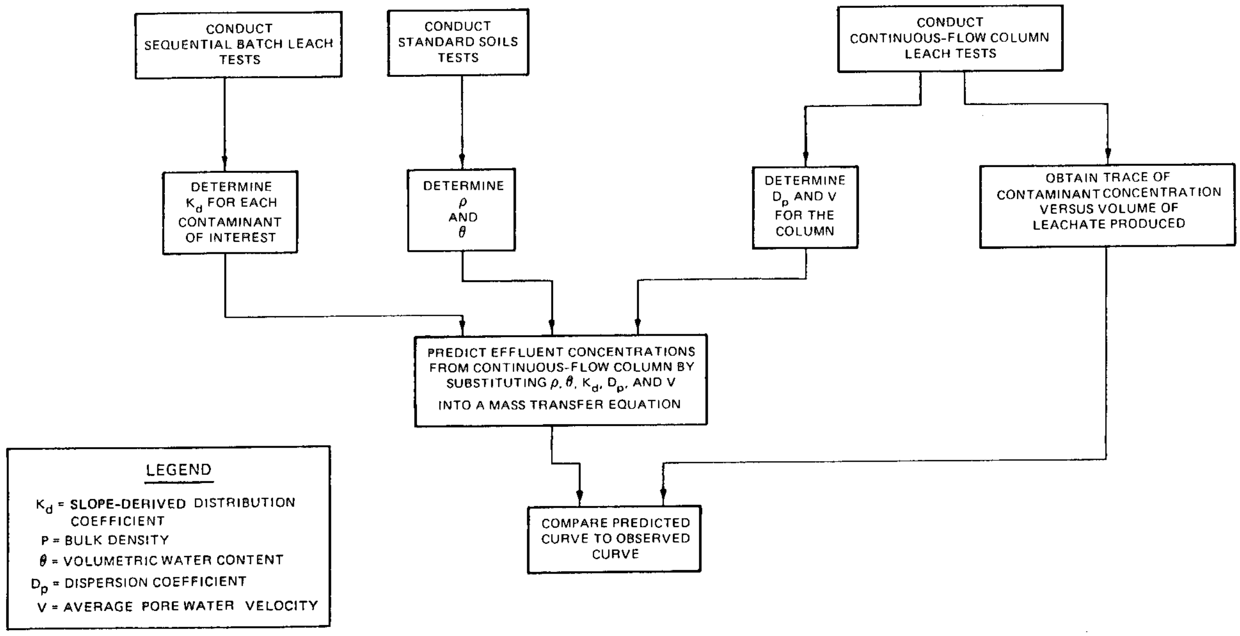


Figure 2. Schematic diagram of integrated approach for examining the source term

## Results and Discussion

### Summary of previous leach testing

Batch testing of Indiana Harbor sediment was difficult because of the oil and grease content of the sediment. Despite the difficulties, anaerobic sequential batch tests for metals produced well-defined desorption isotherms. Aerobic sequential batch tests for metals produced ill-defined clusters. An example for zinc and cadmium is presented in Figure 3.

Polychlorinated biphenyl (PCB) desorption isotherms for Indiana Harbor sediment were characterized by clustering of data. Cluster analysis allowed single-point distribution coefficients to be calculated.

The integrated approach for comparing column and batch test results (Figure 2) was applied to the Indiana Harbor data. PCB results are presented in Figure 4 for two conditions--contaminant leaching governed by equilibrium-controlled, linear desorption (coefficients determined during sequential batch leaching), and no desorption (distribution coefficients of zero). Prediction of PCB elution from columns was within an order of magnitude of that achieved in the tests and was conservative; i.e., predicted concentrations were generally higher than concentrations observed during column testing.

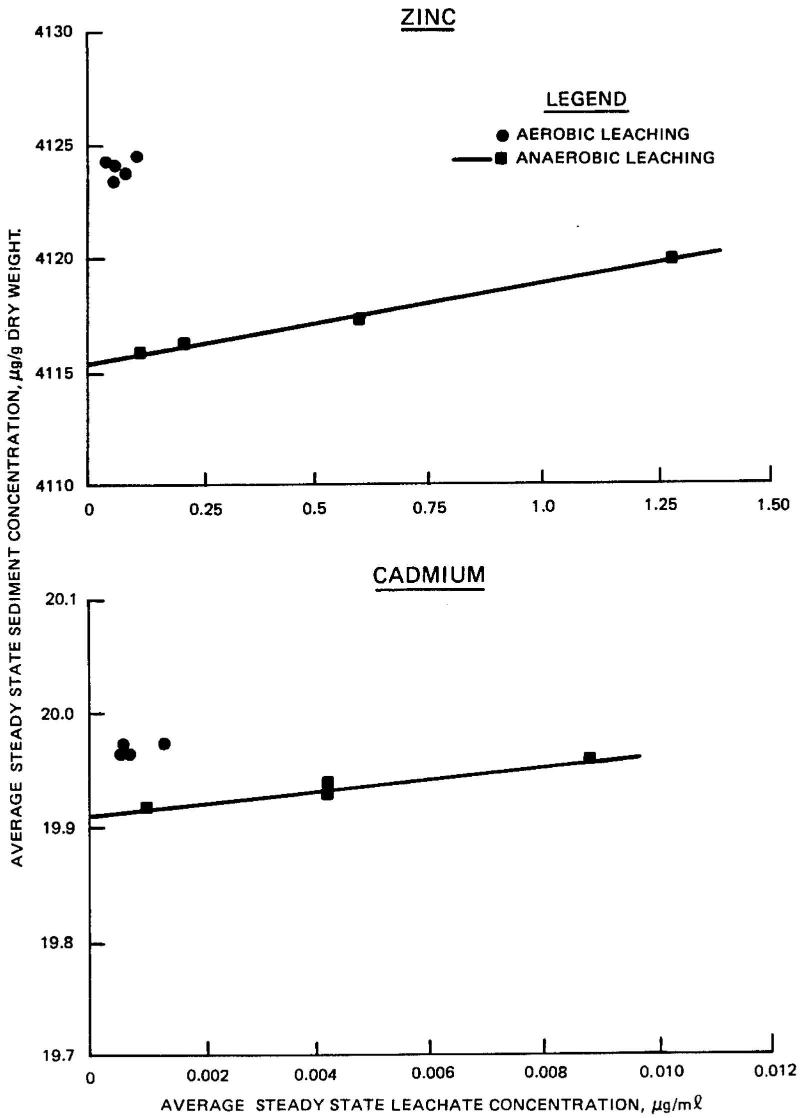


Figure 3. Desorption isotherms for zinc and cadmium in Indiana Harbor sediment

Everett Harbor leaching results differed sharply from those observed for Indiana Harbor. Everett Harbor sediment contaminant concentrations were much lower than those observed in Indiana Harbor, especially for organic contaminants, and Everett Harbor sediment was from a brackish, rather than a freshwater environment. The sediment developed a low pH (4.3) when allowed to oxidize, resulting in mobilization of metals from aerobic sediment during sequential batch leaching. Release of metals during anaerobic batch testing did not follow the classical desorption behavior which was observed for metals in anaerobic Indiana Harbor sediment. Copper desorption from anaerobic Everett Harbor sediment is illustrated in Figure 5.

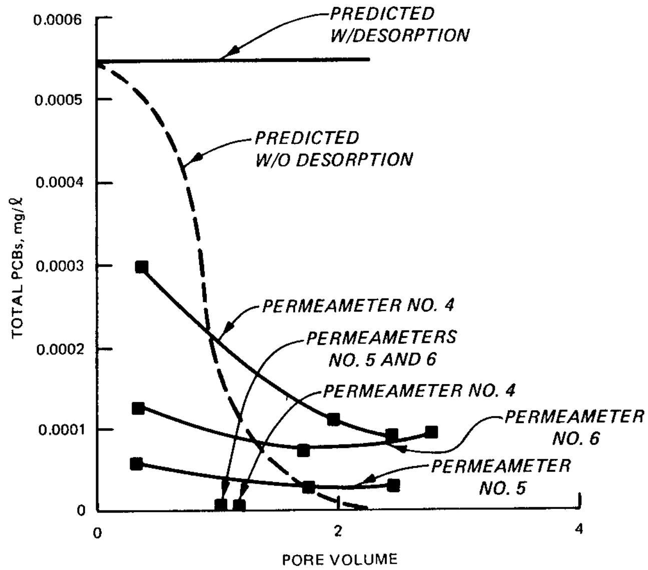


Figure 4. Total PCB concentrations in anaerobic permeameter leachate

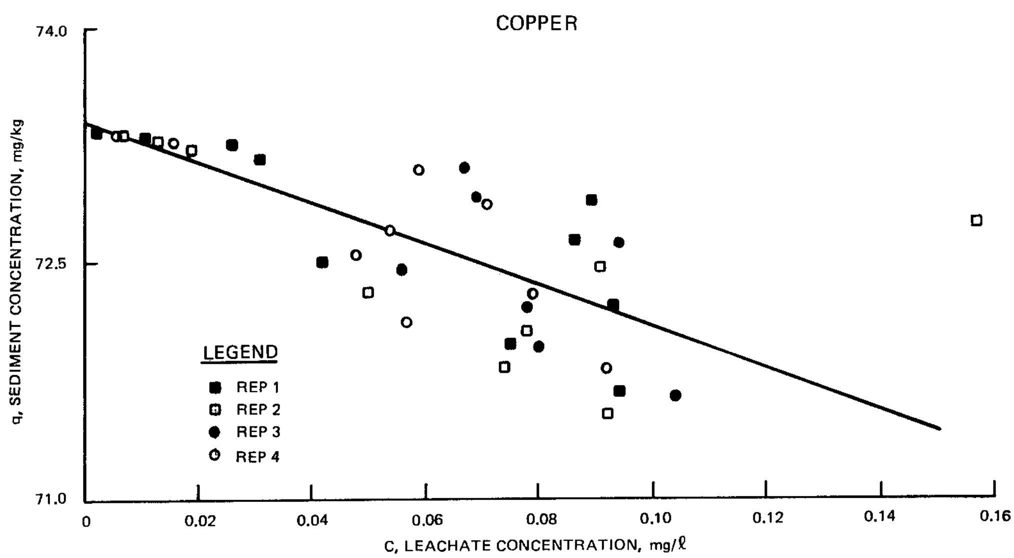


Figure 5. Copper desorption isotherm for anaerobic Everett Harbor sediment

Because the mass transport equation used to implement the integrated approach requires constant distribution coefficients, it was not possible to predict permeameter leachate concentrations using the approach applied to the Indiana Harbor batch and permeameter data. A simplified method that related pore volumes in the sequential batch tests to pore volumes in the permeameter tests was therefore used and gave good qualitative agreement for some, but not all metals tested. A problem was encountered with aerobic sediment during permeameter testing. When aerobic Everett Harbor sediment was placed in a column and flooded, sufficient oxygen demand remained to rapidly deplete all oxygen and return the sediment to an anaerobic condition. Therefore, the column test did not simulate leaching under aerobic conditions.

The New Bedford Harbor site sediments differed from previous sediments tested in that it contained 2,167 mg/kg of total PCB, which is orders of magnitude higher in concentration than observed for Indiana Harbor and Everett Harbor sediments. Many metals in New Bedford Harbor sediment were higher than 1,000 mg/kg, much higher than metal levels observed in Everett Harbor sediment.

The shape of desorption isotherms for metals in New Bedford Harbor sediment was similar to the example given in Figure 4 for Everett Harbor sediment. Aerobic New Bedford Harbor sediment developed a low pH (2.1), resulting in releases of some metals during aerobic batch leaching.

Leaching of anaerobic New Bedford Harbor sediment with distilled water resulted in development of reverse slope isotherms which in some cases turned back toward the sorbed concentration (vertical) axis. The isotherm is illustrated in Figure 6 for total PCB. Further leaching and analysis of leachate showed that as the conductivity in the distilled water leachate decreased, colloidal organic matter and microorganisms containing adsorbed PCB were destabilized, resulting in PCB mobilization in colloidal or microparticulate form.

Significantly lower concentrations of PCBs and some metals were observed in column leachate compared to batch leachate. The reasons for these significant differences are presently unexplained.

As was the case with Everett Harbor, the integrated approach could not be used with New Bedford Harbor sediment because of the type of desorption isotherms obtained. However, simulation of PCB elution during nonconstant partitioning by coupling PCB concentrations to conductivity in the column

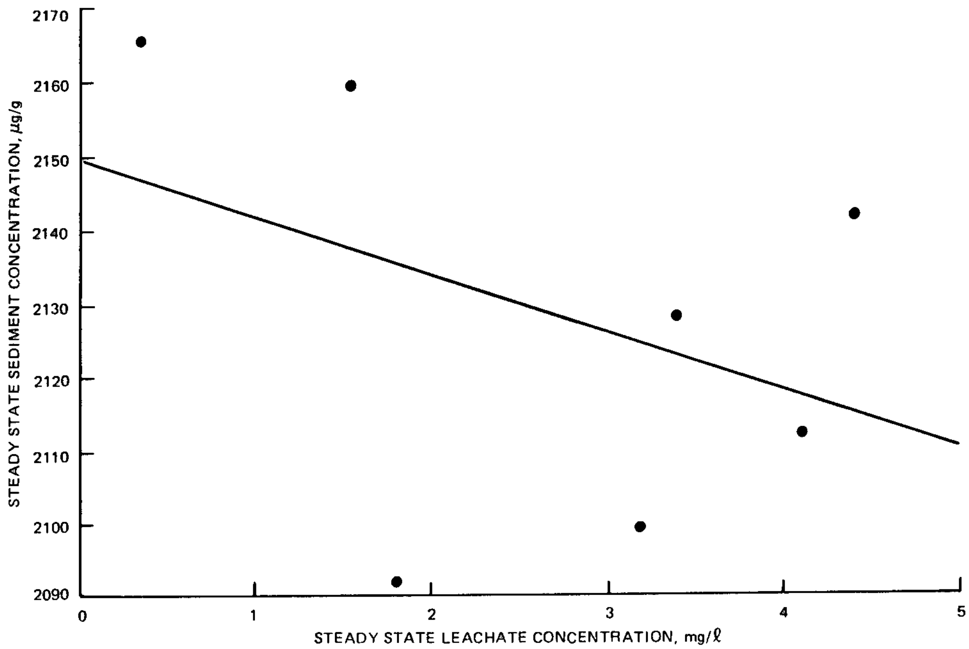


Figure 6. Total PCB desorption isotherm for New Bedford Harbor sediment distilled-water sequential batch leach test

leachate resulted in qualitative agreement in elution trends for predicted and observed PCB elution curves.

Louisiana State University Workshop

Results of the three studies previously summarized were discussed in detail at a workshop on development of leach tests for contaminated dredged material, conducted June 23-24, 1988, in Baton Rouge, LA. The workshop was hosted by the Louisiana Water Resources Institute, the Hazardous Waste Research Center, and the Center for Wetland Resources, all of Louisiana State University. The workshop was organized to gather prominent researchers in the area of contaminant mobility in dredged material for review and evaluation of available leach data on dredged material. Workshop panelists thought that work conducted to date was good and that the work generally validated the basic approaches suggested by the 1984 working group. However, the consensus was that much research remains to be done before a leachate test protocol will be ready for routine use. The following research directions were developed during workshop discussions:

- Redesigning of the column leach tests to include thin-layer columns and improved leachate collection systems.

- Reevaluation of the aerobic column test.
- Investigation of the impact of colloidal systems on interactions between solid and liquid phases.
- Determination of the role of key parameters such as ionic strength, pH, and contaminant-sediment association on leachate results.
- Investigation of desorption kinetics.
- Investigation of techniques for accelerated sediment oxidation.
- Development of a more comprehensive mass transport model for comparing batch and column test results and verification of the model structure.
- Verification of test protocols in a field situation, preferably at a national multiagency research site.

## Future Plans

In the leachate studies conducted to date, each of the sediments tested behaved in a unique manner. Future study will build on the lessons learned in these projects and the research directions identified in the workshop. During the upcoming fiscal year, research will be initiated on basic research needs such as the impact of colloidal systems on interactions between solid and liquid phases, the role of parameters such as ionic strength and pH on leachate quality, an in-depth investigation of desorption kinetics, and design of thin-layer columns and improved leachate collection systems for columns. Research in future years will be a continuation of these efforts as well as reevaluation of the aerobic column tests, investigation of techniques for accelerated sediment oxidation, and refinement of the mass transport model for comparing batch and column test results. Verification of testing protocols developed will then be conducted and predictive techniques for assessing leachate impacts from confined disposal facilities will be finalized.

# References

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